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A review on green energy potentials in Iran

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ABSTRACT

Iran is one of the main non-renewable energy producers in the world due to its plentiful fossil fuel resources. Utilization of natural gas and petroleum in transportation and industrial sectors has been developed vastly in Iran because of their low prices. Consequently, the increasing rate of pollutant formation and depletion of non-renewable fuels have emerged as new challenges in the energy scenario of this country. Since Iran has plenty of fossil fuel resources, alternative fuel and renewable resources have not been taken into consideration seriously. This existing trend of fossil fuel utilization is not according to the sustainable development aims which have been adapted for the country. Recently, controlling the unbridled fossil fuel consumption has become one of the main targets of the Iranian Government. A variety of natural resources in different regions of Iran can be applied as the main sources of renewable and sustainable energy (RSE) and considered as the supplementary energy in the energy mix policies. Biofuel, hydropower, wind, solar and geothermal are the main RSE that can be utilized for energy supply. Moreover, regarding the increasing rate of the population, bioenergy generation from waste materials can play a crucial role in sustainability of waste management strategies. In this regard, the present study has been conducted to evaluate renewable energy potentials from various resources in Iran.

Contents

1. Introduction

Developing country Iran is located in the Middle East in the southern parts of the Caspian Sea, Turkmenistan, Azerbaijan and Armenia and has Pakistan and Afghanistan on the east, Iraq and Turkey on the west, and Persian Gulf and Oman Gulf in the south with many valuable non-renewable and renewable natural resources. The population of Iran is around 73 million and the area of this country is 1,648,195 km^2. Due to various topologies, the climate of Iran is great extremes and mostly semi-arid with an average annual rainfall of 228 mm and with average temperature of 19–38 °C in summer and 10–25 °C in winter [1]. The population of Iran has risen drastically and simultaneously the urban population has increased at a higher rate rather than the rural population. Generally, urbanism is the main index for economic development and production growth; however, it has been claimed that urbanism in Iran is not related to

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economic and social development. In fact, urbanism in Iran has been attributed to the significant income gap between rural and urban areas, the availability of the facilities in cities and the cultivation dilemma problems related to the seasonal drought [2]. Totally, the energy demand increases rapidly by progress in socioeconomic development. Therefore, in the definition of energy supply policies the sustainability and clean environment should be considered to guarantee the people health and the secure energy supplies. Indeed, development strategy based on crude oil exportation exclusively is the main case of unsustainability. Today, the energy of the world is mostly provided by different kinds of fossil fuels like coal, oil and natural gas. Around 66% of required electricity of the world is generated based on fossil fuel utilization. The economy of Iran relies on crude oil export strongly and the fluctuations of oil price impact on country's development [3]. After Venezuela, Saudi Arabia and Canada, Iran holds the fourth largest crude oil reserves in the world. Also, statistics show that Iran is the second largest natural gas reserve in the world [4]. Oil reservoirs are divided among the countries of the world unequally so that more than 98% of oil production is done by 42 nations and less than 2% oil production is related to 70 countries and remaining 70 countries do not have any oil reservoirs [5,6]. Iran benefits enormous oil and natural gas reservoir. According to the estimations, at the end of the year 2011 the natural gas reservoir of Iran is 33.1 trillion cubic meters and oil reservoir is 151.2 thousand million barrel around 15.9% and 9.1% of the world reservoirs respectively. Figs. 1 and 2 depict top 10 oil reservoir nations and natural gas reservoir in the world [7].

Iran's crude oil production is expected to increase from 528.07 ml/d (million liters per day) to 789 ml/d in 2030 and gas production is projected to increase from 110 bcm (billion cubic meters) in the year 2010 to 240 bcm in 2030 [8]. As in other countries, energy is a substantial factor for life quality improvement, social development and economic in Iran. In recent years, the shares of oil and coal in the energy mix of the world were around 33.1% and 27%, respectively, while 54.4% and 44.1% of total energy consumption in Iran have been provided by natural gas and oil, respectively. In some countries like China and USA, coal plays an important role in the energy policies; however, in Iran it is providing just 0.21% of the total energy demand. Kerman and Yazd mines have supplied more than 65% of the total coal production in Iran. It has been reported that coal is only applied in iron and cement industries and there is no coal power plant in Iran yet [9]. As coal, oil and natural gas are non-renewable fossil fuels, the contribution of non-renewable fuels in the energy pattern of the world and Iran is about 81% and 99%, respectively. Despite the existence of plenteous renewable energy resources, the contribution of renewable and sustainable energy in energy mix of Iran is less than 1%. Fig. 3 shows the scenario of energy mix in Iran compared to the world in recent years [10].

International Energy Agency (IEA) has anticipated that natural gas and crude oil will be run out in the next 60.3 and 41.8 years,

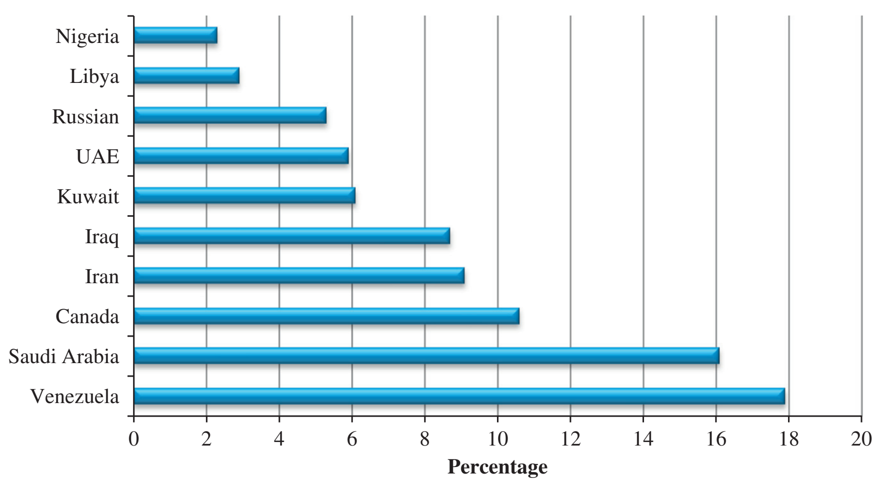


Fig. 1. Top 10 oil reservoir countries in the world [7].

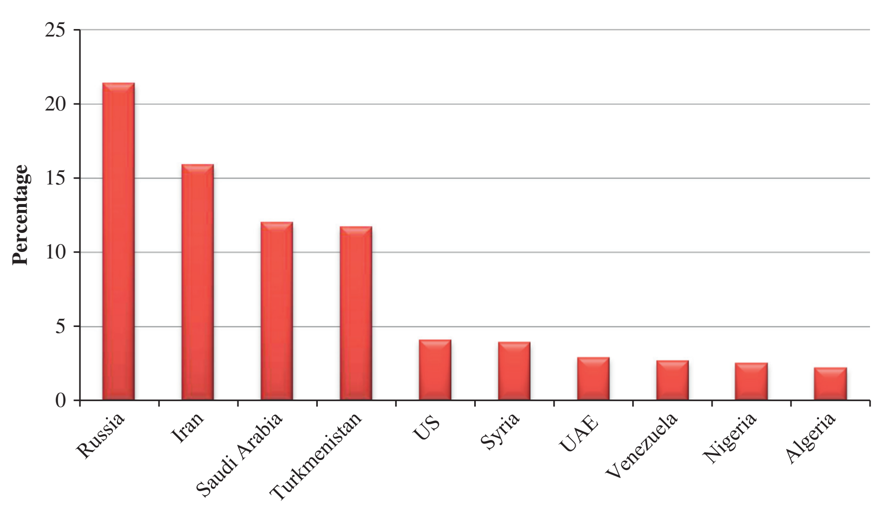


Fig. 2. Top 10 natural gas reservoir countries in the world [7].

respectively; therefore it is expected that RSE will the most important energy sources in future [11]. Regarding the environmental problems created by fossil fuel consumption renewable and sustainable energy resources should be taken into consideration by different countries in the world. The contribution of RSE resources in transportation system and power generation has been projected to increase 7% and 29%, respectively, by the year 2030 [12]. The primary energy demand in the year 2011 in Iran was reported to be 228.6 MT which had 2.5% increment compared to the year 2010. Fig. 4 demonstrates the trend of primary energy demand in Iran during the last decade [7].

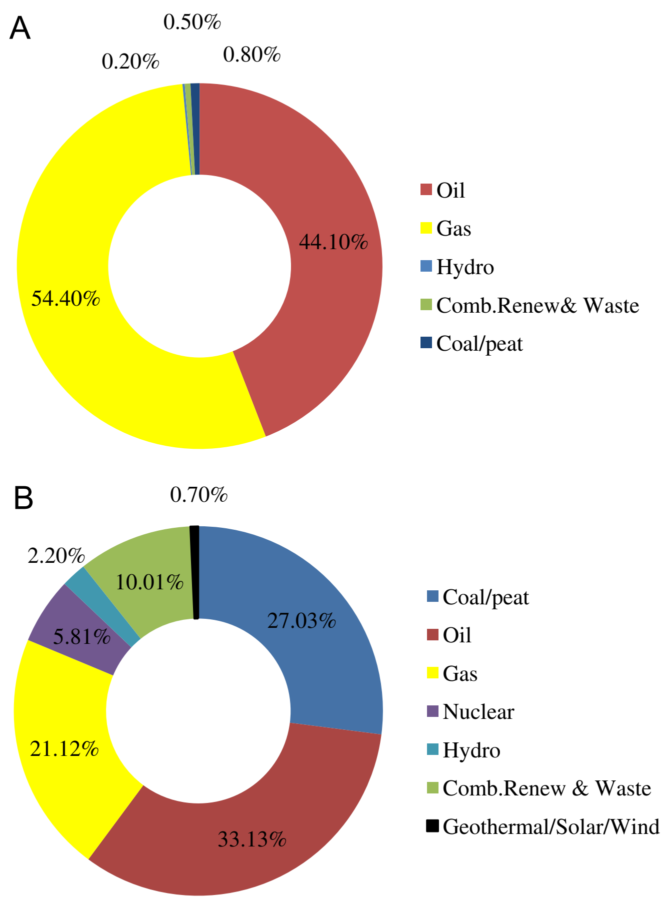


Fig. 3. The scenario of energy mix in Iran (A) compared to the energy mix of the world (B) [10].

Electricity demand in Iran has been reported to be 50,000 MW which is around 80% of what has been generated by the fossil fuel consumption. It has been projected that Iran's electricity demand will be 200,000 MW in 2030. Obviously, fossil fuel resources will not cover this percentage in 2030 [13]. This increasing trend of energy demand will be met by Iran by becoming the importer of energy in future and some new strategies should be taken into account by Iranian government in the case of energy mix. Recently, transition to the renewable and sustainable energy resources has been accepted as a crucial factor in energy mix by Iranian Government and different programs for green energy development have been established by Renewable Energy Organization (REO) of Iran. Also, Research Institute of Petroleum Industry (RIPI) formed Renewable Energy Initiative Council (REIC) to organize RSE development in Iran in 2008. Generation of 2000 MW energy has been planned based on RSE resources' utilization until the year 2015 by the Iranian Government; therefore some private companies signed contracts to establish biomass and wind power plants with 600 MW and 500 MW capacities respectively at 2010. It has been also tried to make RSE commercial by the Iranian Ministry of Energy by purchasing renewable energy from private sectors at world market prices. A feed-in-tariff for biomass and wind energy resources of approximately 13 cents/kWh could be an incentive factor for private sectors. In 2012, Iran Government dedicated €500 million from the National Development Fund (NDF) for green energy development. Indeed, Renewable Energy Organization of Iran (SUNA) which is the state-sponsored supported by Ministry of Energy works on solar energy development and its annual budget is around US$60 million [14]. The development of RSE not only plays crucial role in worldwide energy strategy but also has great impact on greenhouse gases (GHGs) mitigation [15]. GHGs are generated in the process of energy production, conversion, distribution and consumption in the world. The increasing rate of GHGs generation due to exorbitant fossil fuel consumption has serious impacts on human life and especially on global warming (GW) phenomena [16]. Also, around one-third of CO_2 emission is adsorbed by oceans each year which created acidic circumstance and has adverse effects on biodiversity of marine ecosystem [17]. CO_2 is the main GHGs generated by an upward trend during the last decade in Iran and total CO_2 emission from energy consumption has been reported to be 624.855 million tons in the year 2011. As the main part of energy demand of Iran has been provided by fossil fuels, Iran has become one of the 20 countries to have a contribution in 75% of GHGs generation [18,19]. Recently, the rate of CO_2 emission from different resources in Iran passed the Kyoto

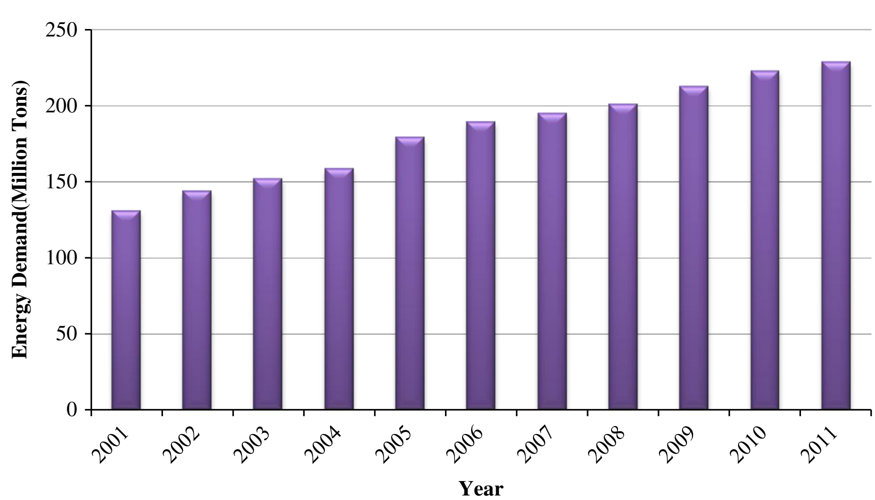


Fig. 4. Primary energy demand in Iran [7].

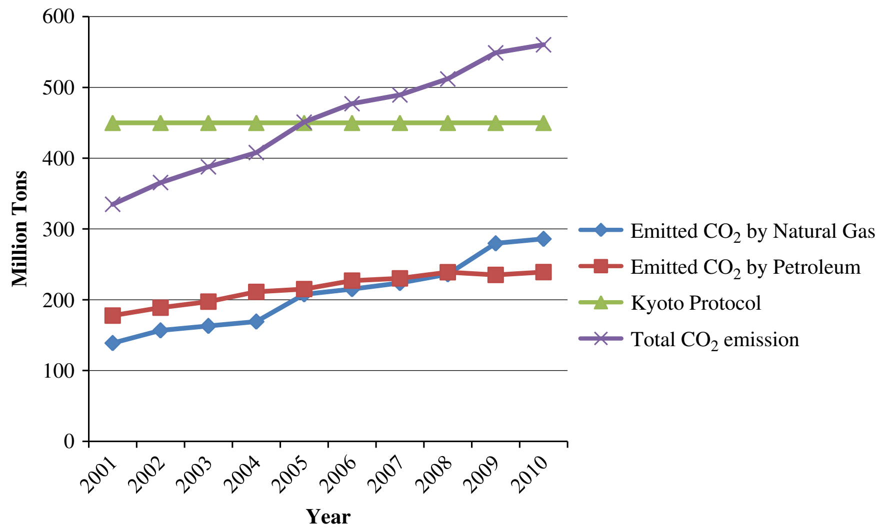


Fig. 5. The trend of CO_2 emission in Iran [19].

Protocol (KP) limitations and this country has been introduced as the 10th worldwide country in carbon dioxide generation. Fig. 5 shows the trend of CO_2 constitution in Iran [20].

2. Biomass utilization in Iran

Climate and terrain diversity in Iran are the basic factors for the cultivation of various energy crops appropriate for biodiesel production. Around 7% of Iran′s area has been covered with forest which can be great sources for biofuel products such as biodiesel and bioethanol. In Iran, agricultural sectors have important roles in rural economy as well as macroeconomic performance. Various regions in Iran have the capability for different crops cultivation due to climate diversity. More than 30% of total lands can be cultivated in this country if required water is supplied; however, statistics prove that only 12% of this capability has been applied for the cultivation. On the other hand, it has been reported that around 19.6 million ton (MT) residues have been generated annually which are mostly burned [21,22]. Agricultural residue, municipal solid waste (MSW) and animal waste can be applied as the main sources of bioenergy in Iran. Also, huge amounts of cultivation crops and forests can be the main source of bioethanol and biodiesel production in Iran.

2.1. Biomass waste

Agricultural wastes are great energy resources without nutritional value to human beings. Huge amount of agricultural wastes like weeds and leaves of the plants, hay and stubble of cereals and garden products are produced in different stages of agricultural process which can be applied as green energy resources. The potential of biomass waste production has been estimated to be 8.78 MT agricultural, 7.7 MT animal waste and 3 MT municipal solid wastes (MSW) in Iran. Fig. 6 shows the share of potential energy biomass waste resources in Iran [7].

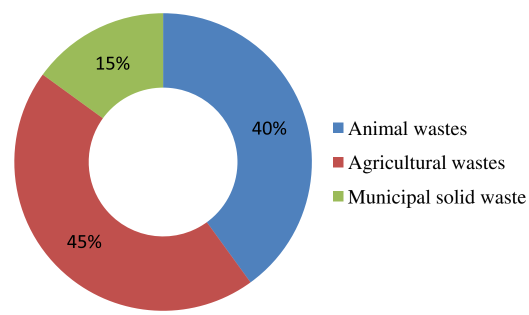


Fig. 6. The share of potential energy biomass waste resources in Iran [7].

Development in food industries especially in animal husbandry is one of the main consequences of increasing rate of population in Iran. Therefore, annual animal dung production has increased rapidly. Animal dung has been applied as a fertilizer in farms vastly. Biogas capturing from livestock dung and energy extraction from these waste materials are economically and environmentally important [23]. The rate of MSW production in Iran has been reported around 0.2–0.5 kg per person per day. Some factors such as incomes of the people and consumption pattern have significant impacts on this value. For instance, MSW generated from inhabitants of Tehran as the capital of Iran is reported to be 0.88 kg per person per day [24]. Fig. 7 demonstrates the composition of MSW in metropolis Tehran, the capital of Iran [25].

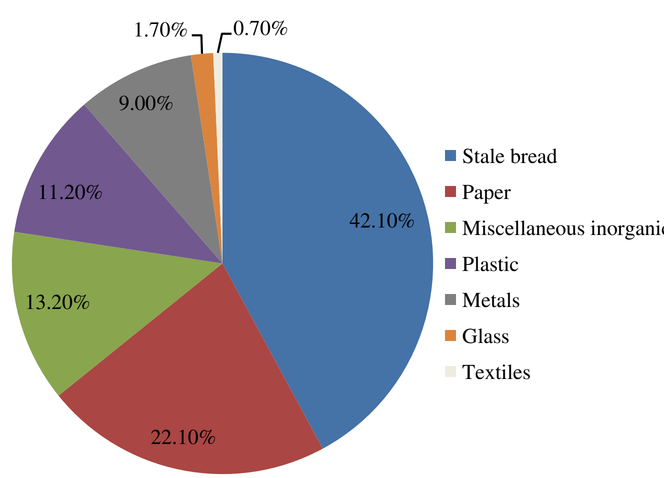


Fig. 7. The composition of MSW in metropolis Tehran [25].

The incidence of infectious diseases can be augmented due to increasing rate of polluted MSW generation. Therefore, some policies should be adopted to manage the huge amounts of generated MSW appropriately. Landfilling is the main strategy

for MSW elimination in Iran. However, MSW can be an excellent source of biogas, and by applying sustainable policies, energy recovery can be implemented. Around 15 MT solid wastes have been generated annually in Iran which is capable to generate approximately 3 MT renewable energy each year [26]. Recently, some feasibility studies have been done in the construction of 10 MW power station based on MSW biogas utilization by REO in the cities having population over 250,000 and first biogas power plant with the capacity 460 kW has been commissioned in Saveh city [27]. Indeed, three biomass stations in Saveh, Mashhad and Shiraz with capacity of 600 kW, 650 kW and 1060 kW, respectively, will be installed by the Iranian Government [28,29].

2.2. Biofuel and bioethanol production in Iran

Recently, liquid biofuel has emerged as the supplementary or alternative for petroleum fossil fuel due to the successful application in diesel engines and tremendous investments have been carried out in biofuel development throughout the world. Compared to the fossil fuel, biofuel has some advantages such as GHGs reduction, raising development in rural areas of the country, increasing the security of natural energy and warranting the future energy of the country [30]. Production and utilization of biofuel have increased vastly during the last decade in the world and consumption of low blends biodiesel has become routine in most of the countries. For example, it has been reported that 21 EU countries utilized biofuel which consists of biodiesel and ethanol of 76% and 24%, respectively, from 2002 to 2005 [31,32]. Table 1 shows the targets for biofuel sharing by some EU members from 2005 to 2010.

Table 1
The share of biofuel in energy mix in some EU members (in %).

Member state	2005	2006	2007	2008	2009	2010
Austria	2.5	2.5	4.3	7.75	5.75	5.75
Belgium	2	2.75	3.5	4.25	5	5.75
Czech Rep	3.7	1.75	1.63	2.45	2.71	3.25
Greece	0.7	2.5	3	4	5	5.75
Italy	1	2	2	3	4	5
Latvia	2	2.75	3.5	4.25	5	5.75
Portugal	2	2	3	5.75	5.75	5.75
Slovakia	2	2.5	3.2	4	4.9	5.75
Slovenia	0.65	1.2	2	3	4	5

Biodiesel production and utilization was applied not only in developed countries like Germany, Italy and France but also in developing countries like Malaysia, Brazil, Indonesia and Argentina which invest in biodiesel production vastly [33]. Different blends of biofuel can be consumed in diesel engines without substantial modification. Furthermore, the GHGs emissions from biofuel combustion decrease in comparison with fossil fuel combustion. Also, the contribution of biofuel in energy mix not only promotes the rural areas development but it can increase the energy security of the country. So many feasibility studies have been done by various scientists to investigate the possibility of biodiesel and bioethanol production in the Asian countries [34–37]. In 2012, the capability of biodiesel production and utilization in Malaysia was investigated by Hosseini et al. [38]. Qiu et al. [39] studied the impacts of bioethanol development on China's agricultural economy. Optimization of biodiesel production in India has been researched by Leduc et al. [40]. The potential of biomethanol application in Indonesia was studied by Suntana et al. [41]. Phalan et al. [42] anticipated that biodiesel can supply a significant part of energy demand in Asian countries in future. Biodiesel production from various sources, application of various blends of biodiesel in diesel engine and the feasibility of 5% ethanol utilization as a blend in 95% of gasoline in automobiles are some investigations that were done by Iranian scientists [43–46]. The diversity of climate and terrain in Iran is an excellent opportunity for crops cultivation for biofuel production. A variety of crops such as rice, wheat, pistachio nuts, barley, sugar cane, cotton and sugar beets which are primary sources of bioethanol feedstock have been cultivated in Iran. Sugar beet molasses and sugar cane with approximately 500 million liters production annually have been mentioned as the main sources of bioethanol in Iran. Khuzestan Province located in the south west of Iran has great potential for sugar cane production due to plenty of irrigation water supplied by different rivers like Karun and the qualified lands [47]. It has been stated that around 17–20% of total crops production converts to agricultural residue. Although, huge amounts of wasted crops have been generated by agricultural activities, those are not totally taken into account for biofuel production. Around 17.86 million tons generated crops residue have capability to produce 4.91 billion liter bioethanol annually [48]. Around 15 million ton wheat is produced in Iran annually which approximately 50% of wheat production is lost as waste of residue. These waste materials are capable of producing 3 billion liter bioethanol. As about 24 billion liter gasoline has been

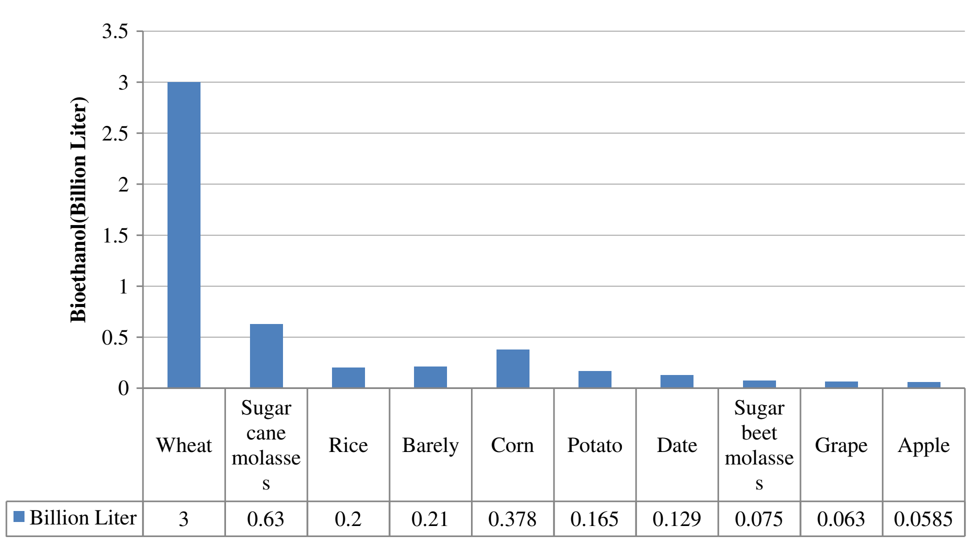


Fig. 8. Potential of different agricultural crops for bioethanol production in Iran [50].

consumed annually in Iran, bioethanol utilization for biodiesel blend E5 production for spark ignition engines consumption has great capability [4]. Also, algae and cellulosic materials can be cultivated vastly to produce biodiesel in Iran [49]. About 17.86 million tons generated total crop waste has the potential to produce around 5 billion liters bioethanol annually. Around 20% of 1.5 million tons produced edible cooking oil is released as waste which can be considered as a feedstock for biodiesel production. Based on FAO statistics the potential of different agricultural crops for bioethanol production in Iran has been demonstrated in Fig. 8 [50].

Recently, some researches have been done to evaluate the capability of bioenergy generation based on agricultural waste utilization in Iran which promises development in technology of biofuels production [51–67]. Although, more than 33% of the Iran′s land has the capability for crops cultivation in sufficient water conditions, just approximately 12% of the land is under cultivation. Around 7% of Iran′s area has been covered with forest. The byproducts from Iran's forests, which are located in the Alborz Mountain in the north and Zagros Mountain in the west, have an excellent capability for biofuel production. During 1960–1985, wood from these jungles was applied as a traditional energy resource in western and northern parts of Iran. The estimated area of these jungles exceeds 1.9 million hectares which could be a great source of renewable energy. Moreover, fishery is done vastly in the Caspian Sea in the north, Persian Gulf in the south and various inland rivers and produced fish oil can be applied as an acceptable feedstock for biodiesel production. The outlook of different blends of biodiesel and bioethanol production has been illustrated in Figs. 9 and 10 respectively [10].

Ardebili et al. [8] studied the possibility of biodiesel production from edible oil seeds utilization in different states of Iran. It has been mentioned that biodiesel produced from edible oil seeds have capability to replace around 2% of consumed diesel. In other words, B2 (2% biofuel and 98% diesel) as the optimum alternative fuel for CI engines can be achieved just by edible oil seeds biodiesel production. Fig. 11 shows the schematic plan for biofuel production from resources to end use utilization [10].

According to the report from agricultural ministry of Iran, Fars, Golestan and Razavi Khorasan are the main states for oil seeds plantation. Soybean, canola and cotton have high potential to be applied as feedstock for biodiesel production in Iran. Also, other oil seeds such as corn, olive, sunflower and sesame are capable to contribute in biodiesel production in Iran. Fig. 12 demonstrates the share of different Iran's provinces in cotton, soybean and canola production. Indeed, Fig. 13 depicts the potential of other oil seeds for biodiesel production in Iran [8].

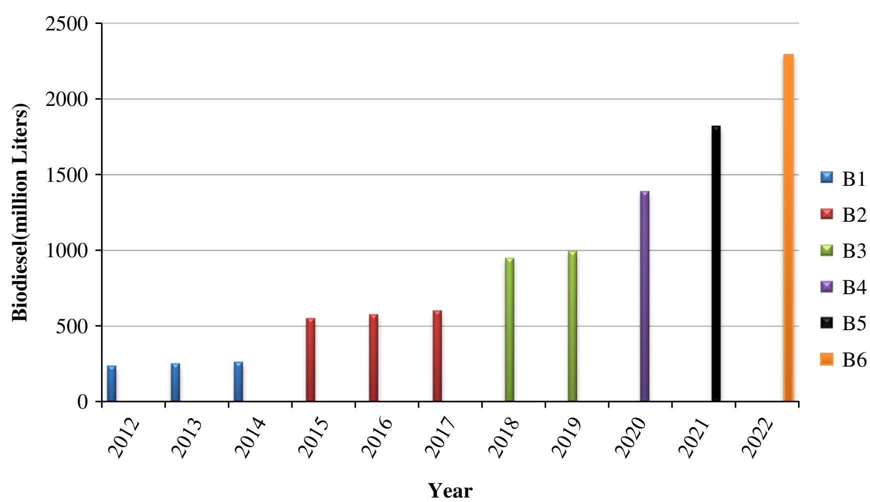


Fig. 9. Outlook of biodiesel production based on different blends in Iran [10].

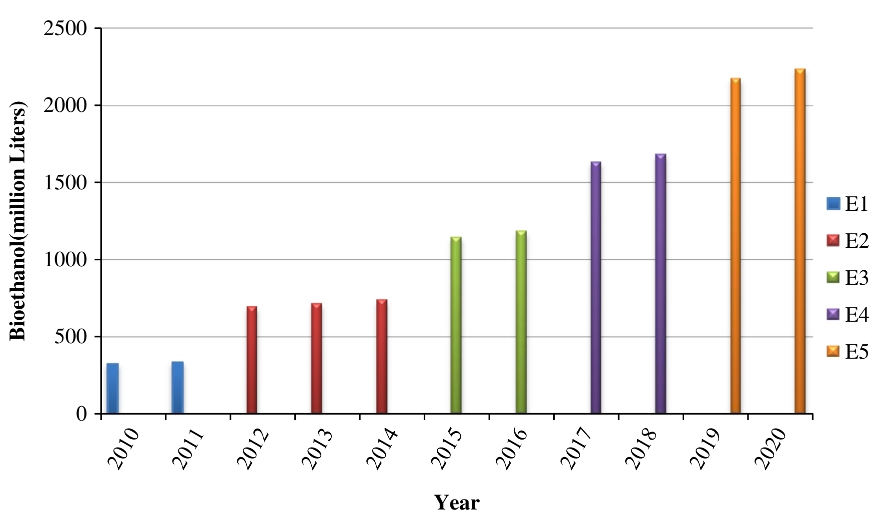


Fig. 10. Outlook of bioethanol production based on different blends in Iran [10].

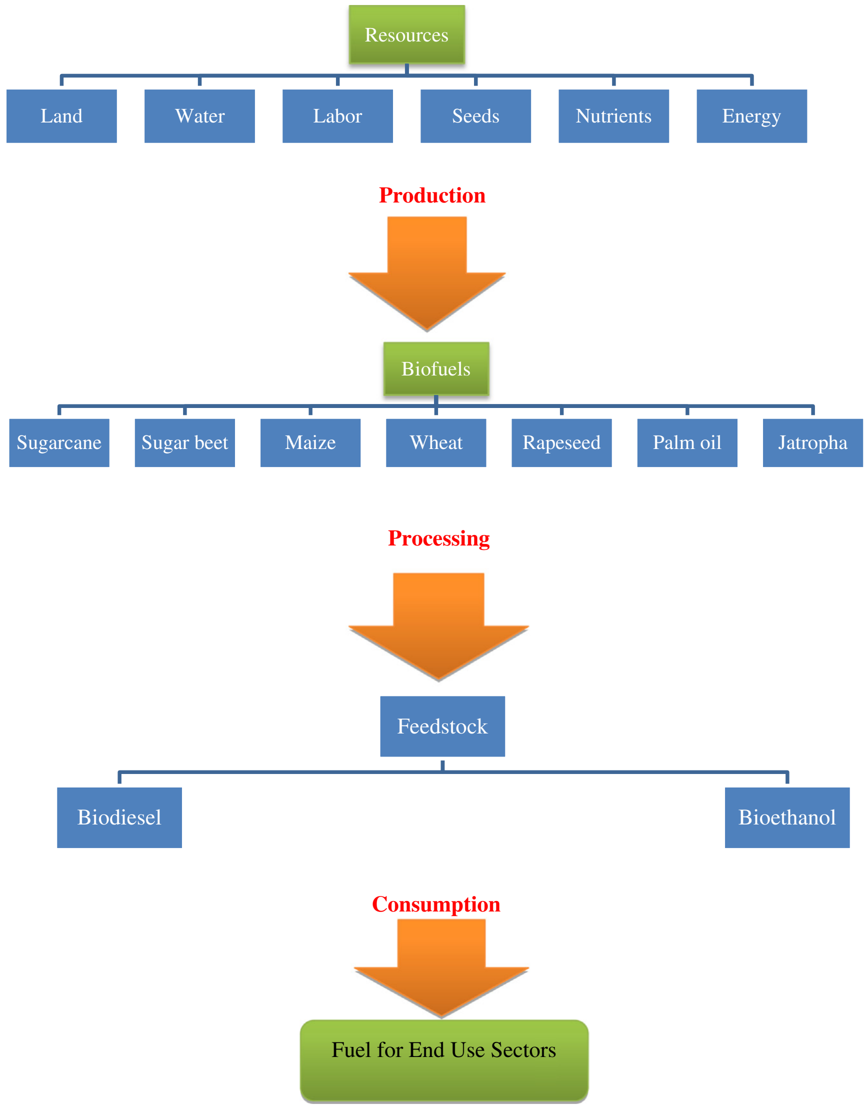


Fig. 11. Schematic plan for biofuel production from resources to end use utilization [10].

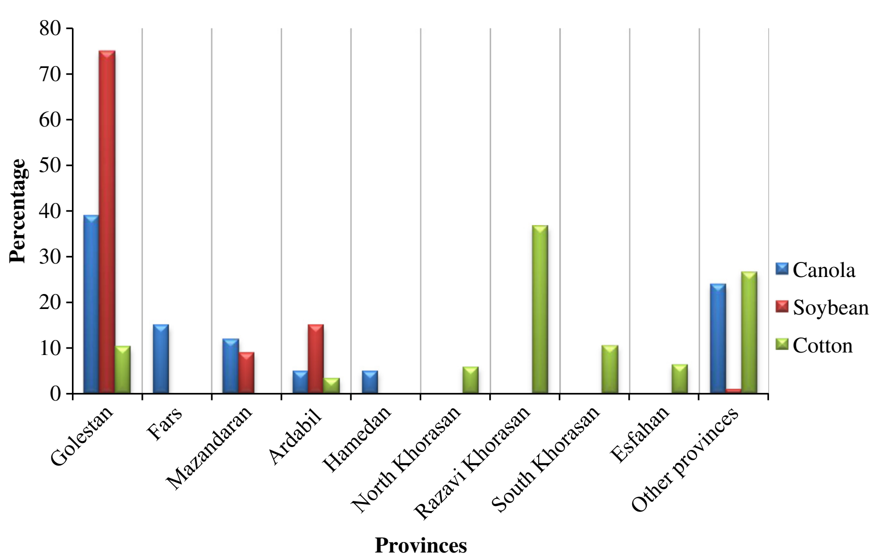


Fig. 12. The share of different Iran′s provinces in cotton, soybean and canola production [8].

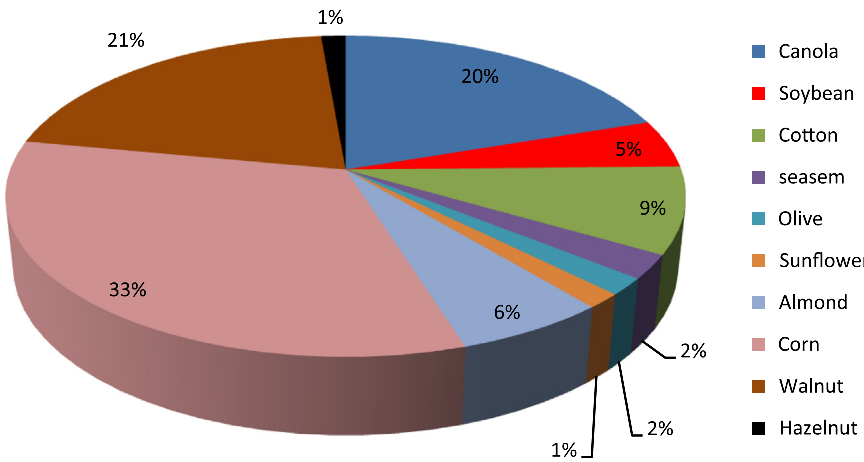


Fig. 13. The potential of different oil seeds for biodiesel production in Iran [8].

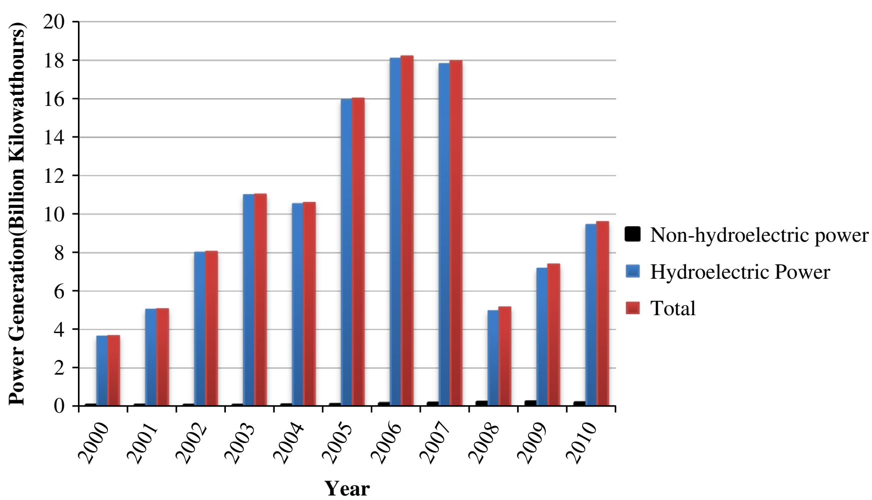


Fig. 14. Total power generation based on hydropower generation and non-hydroelectric renewables from 2000 to 2010 in Iran [69].

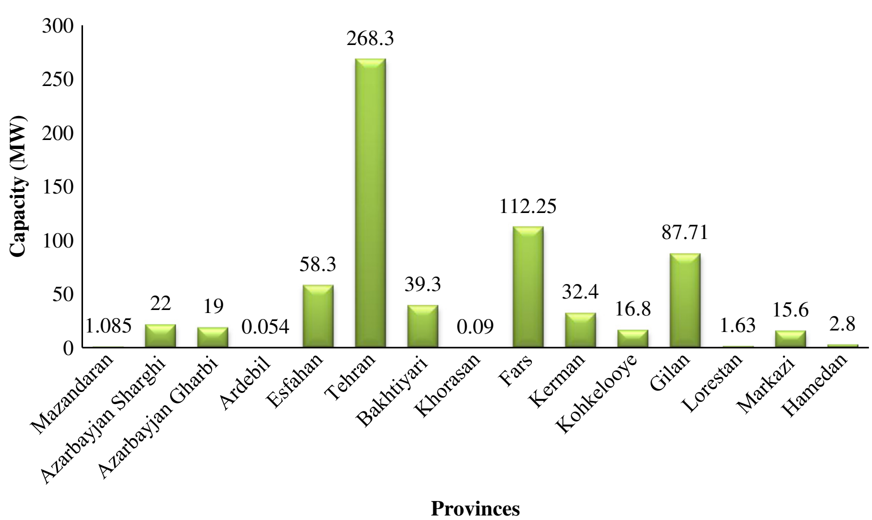


Fig. 15. Electricity generation by 36 small hydropower plants in Iran [9].

3. Hydropower

The price of hydropower illustrates to be more competitive than other renewable resources, equal to \$0.04/kWh (including transmission expenses). The main purposes of hydro-dams construction are water supply, irrigation of the cultivated lands, and controlling the flood and power generation. GHGs generation can be eliminated by hydropower electricity generation [68]. Statistics confirm that hydropower generation has been developed in Iran and it has become the most important RSE for power generation in this country. Fig. 14 shows that total power generation consists of hydropower generation and non-hydroelectric renewables from 2000 to 2010 in Iran [69].

The total capacity of hydropower generation by 42 active stations is approximately 7672.5 MW which is more than 91% of the total hydroelectricity that has been generated by only six plants located in Khuzestan province by 6995 MW. More than 91% Iran′s hydroelectricity is generated by large hydroelectric plants with capacities of more than 100 MW, 8% at medium size between 10 and 100 MW and the remaining produced by microsize hydropower plants (less than 10 MW). The contribution of mini hydropower plants in energy supply is very low and Fig. 15 shows the capacity of electricity generation by 36 small hydropower plants in Iran [9].

So many strategies have been adopted by Iranian government to intensify the role of hydropower in energy mix of the country. Today, the most important hydropower project is implemented in Chaharmahalo Bakhtiyari with total capacity 1342.5 MW [70].

4. Wind energy

Recently, wind technology has attracted attentions and many investigations have been done on wind power generation in different countries [71–74]. In fact wind energy is one of the most economical technologies among RSE in electricity generation and it is projected that this development trend will also continue in the future [75]. United States, China, Germany, Spain, and India are mentioned as the pioneers of wind turbines technology [76]. The geographical conditions of Iran augment the probability of strong air flows in different months of winter and summer due to its low air pressures compared to the high air pressures in the northwestern and north parts of the country [77]. In winters, cold northerly winds blow due to various pressures between Atlantic Ocean and the Mediterranean sea from the west as well as central Asia from the east and the atmosphere over Iran. Indeed, eastern Indian Ocean wind and western Atlantic Ocean wind are the main cause of the well-known of 120 days wind Sistan during the summers in Iran. Despite the high capacity of wind energy in Iran, Iran′s wind power plants have not been developed according to expectations [78]. The initial estimations evaluated Iran′s wind energy capacity of about 6.5 GW [79]. However further studies confirm that Iran′s wind potential can increase up to 15 GW [80]. Iran is the only country in the Middle East which has installed wind turbines on a large scale. Most of the studies confirm that application of wind turbine technology in Iran is more suitable than other RSE sources. According to evaluations the annual wind power generation is tantamount to 0.12 million barrels crude oil in recent years. Electricity generation from wind power stations has growth of 27% from 1998 to 2008 in Iran. Fig. 16 shows the rate of wind power generation during that period [81].

Most of the Iran′s wind power generation sites are located in Gilan and Khorasan provinces. Also, exploitation of wind energy in Qazvin and Yazd province has been carried out recently [82]. In the year 2012, assessment of wind energy in Iran was investigated by Alamdari et al. [83]. Feasibility studies confirm that electricity generation by local winds in other areas of Iran such as Semnan [84], Tehran [85], Yazd [86], North and South Khorasan [87] provinces and Shahrbabak in Kerman province [88] can be affordable. Furthermore, investigations verify that the installation of offshore wind turbine can be feasible in Iran [89]. Manjil power station with capacity around 61,180 kW is the main wind power plant located in the north of Iran in Gilan province. Also, Binalood with 28,640 kW and Ventiz Dizbad with 260 kW total electricity generation are the other main wind power stations in Iran [9].

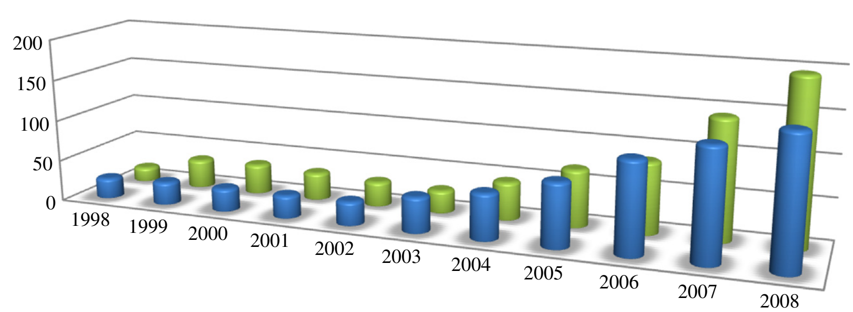
5. Solar energy

The improvement in efficiency of solar panel is the main cause of solar energy development in the world [90,91]. Today, solar energy is being utilized vastly in many countries for power generation as well as heat production [92–95]. Based on published statistics by IEA, the growth trend of solar energy is higher than other RSE during these years. Table 2 depicts the trend of different RSE growth in the world [11].

Different geographical positions in Iran have various potentials for solar energy. The average of solar radiation of Iran has been recorded about 19.23 MJ/m^2 [96]. Solar energy in the north and south of the country has been recorded 2.8 kwh/m^2 and 5.4 kwh/m^2 respectively [81]. In the central regions of Iran the climate is

Table 2
The trend of different RSE growth in the world.

RSE	The rate of growth (%)
Solar energy	42.3
Wind energy	25.1
Biogas	15.4
Liquid biomass	12.1
Solar thermal	10.1
Geothermal	3.1
Hydro	2.3
Solid biomass	1.3
Total	1.9



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of Wind Turbines	25	28	28	28	29	43	56	77	110	133	155
Wind Power Generation(GWh)	17.59	35.04	36.54	33.66	30.28	27.62	46.1	69	86	143.4	196.27

Fig. 16. The number of wind turbines and rate of wind power generation in Iran [81].

very hot and dry and the sunshine average has been reported 3200 h per year [97,98]. Abedi et al. [99] investigated the possibility of solar air collectors for heating the buildings of Isfahan province in the central region of Iran. Dehghan et al. [100] investigated the electricity generation by solar and wind energy in Yazd province located in the central part of Iran. It has been stated that the central part of Iran has great capability to utilize solar and wind energy due to its especial hot and dry climate. Also, the biggest gas–steam–solar power station in the Middle East of the capacity of 467 MW has been installed in Yazd province [100]. The feasibility of solar chimney power plant insulation in different regions of Iran was investigated by Asnaghi et al. [101] and Sangi et al. [102]. Besarati et al. [103] stated that the highest solar capacity factor was achieved in Bushehr located in the south with 26.1% and the lowest one was in Anzaly in the north with only 16.5%. Recently, Shiraz solar power plant of 250 kW has been operated in the south of Iran. Based on the latest published statistics, electricity generation by solar energy showed some fluctuations in the last decade in Iran and that means solar energy has not been taken into account seriously in the energy mix. Fig. 17 depicts power generation by solar energy in Iran [69].

Although Iran has great potential for solar power generation, limited investigations have been done for solar energy in Iran. The main reason is the plentiful oil and gases reservoir in the country which led to the low price of fossil fuel for electricity generation. Despite the high initial cost of photovoltaic (PV) systems, tendencies to utilize PV have been increased throughout the world due to their low maintenance and silent operation [104–106]. Doorbid solar power station which is located in Yazd province is the first PV solar site in Iran with 5 kW DC capacity which was established at 1993. The second PV site was run in 1998 in Hosseinian and Moalleman villages in Semnan by 27 kW AC capacity. Recently, the capacity of these solar power plants has raised to 10 kW DC and 92 kW AC [107,108]. In order to stimulate private sectors some new subsidies have been dedicated to solar power generation related industries by Iranian government to make solar energy a competitive energy resource for non-renewable power plants. However, low price of fossil fuels, PV high prices and lack of comprehensive studies about solar energy in Iran make the investment in solar energy insecure [109].

6. Geothermal

Huge amount of heat is generated by earth′s internal elements decomposition. In the lower layers of the earth the intensity of heat

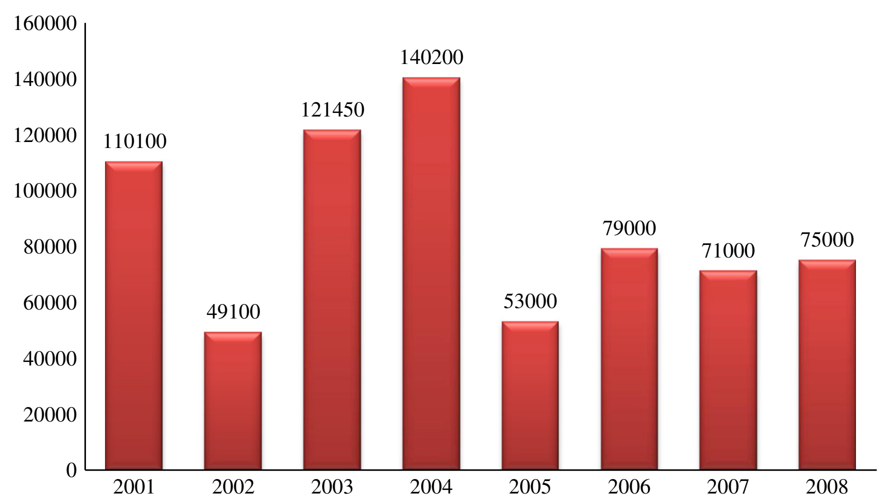


Fig. 17. Power generation by solar energy in Iran [69].

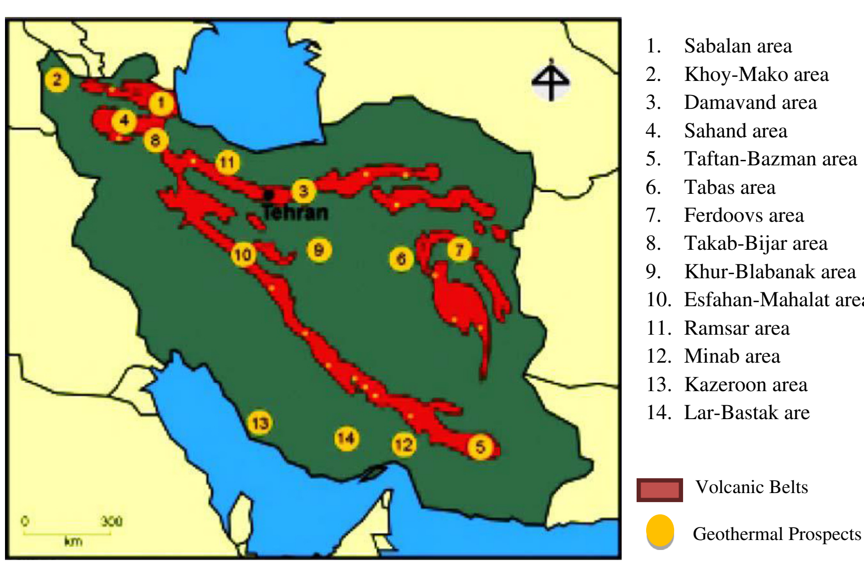


Fig. 18. The situation of geothermal energy potential in Iran [112].

is so high that soils and stones melt. The temperature of water can increase up to 150 °C if it passes through such a region and this can be applied for power generation [110]. Geothermal energy plays a minor role in energy supply scenario of the world; however the availability and environmentally friendly characteristic of this energy have persuaded governments to invest in this RSE [111]. By the year 2010, the total geothermal energy utilized throughout the world was reported to be 11 GW which accounts for 67.2 TWh of electricity generation. The five leading countries in geothermal utilization are the US (3.1 GW), the Philippines (1.9 GW), Indonesia (1.2 GW), Mexico (near 1 GW) and Italy (0.9 GW) [112]. Currently the price for geothermal electricity has been reported between $0.04 and $0.07/kW [113]. The potential of geothermal power generation in Khoy located in Azarbaijan Gharbi province, Sabalan Ardebil province, Sahand in Azarbaijan Sharghi and Damavand in Tehran province was verified in Primary studies. Investigations prove that around 8.8% of total land of this country is capable for geothermal energy production. Fig. 18 illustrates the situation of geothermal energy potential in Iran [114]

Iran has high potential for electricity generation by geothermal energy because it is located on the geothermal belt. Meshkin Shahr power station constructed as a Combined Heat and Power (CHP) station with a capacity of 55 MW is the main geothermal power station in Iran [115,116]. The capacity of Meshkin Shahr geothermal power plant can be increased to 200 MW to produce 410 GWh of electricity [9].

7. Conclusion

Besides water, food, education, diseases and environmental issues, energy has become one of the main priorities of humankind during the last century. In developing countries, energy is the fundamental factor for population fulfillment and development purposes. Technology advancement and social–economic development are in debt of fossil fuel consumption and this fact that fossil fuel resources run out soon has become one of the main concerns of humankind. RSE utilization would also contribute conspicuously to decrease GHGs emissions and related global warming effects. The overview of fossil fuel reserves, energy demand and strategies for energy supply, the status of greenhouse gases generation and the scenario of RSE in Iran have been presented in this study. As the economy of Iran strongly relies on oil and gas export and the fluctuations of oil price impact on country's development, investment on RSE has been highlighted more recently. Indeed, the increasing rate of GHGs generation in Iran has convinced the government to invest in RSE development. In Iran, alternative fuels such as bioethanol and biodiesel produced from crops and agricultural waste materials have great potential to be utilized in transportation systems and industrial sectors to decrease the dependency on fossil fuels and to reduce their negative impacts on the environment. Furthermore, by increasing the population of Iran waste material generation has been augmented and biogas released from waste materials has great potential to be applied as a source of RSE. Solar and wind energy can be obtained vastly in central regions of Iran. Investment on RSE resources should be taken into account seriously by Iranian government because the unique geographical situation of Iran gives a great opportunity for various renewable energies generation.

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References

[1] Hamzeh Yahya, Ashori Alireza, Mirzaei Babak, Abdulkhani Ali, Molaei Masoumeh. Current and potential capabilities of biomass for green energy in Iran. Renewable and Sustainable Energy Reviews 2011;15:4934–8.
[2] Bakhoda Hossein, Almassi Morteza, Moharamnejad Naser, Reza Moghaddasi, Mostafa Azkia. Energy production trend in Iran and its effect on sustainable development. Renewable and Sustainable Energy Reviews 2012;16:1335–9.
[3] Heshmatzadeh M. Iran and oil sociology of political sociology of oil in Iran. Tehran: Recognition Center of Islam and Iran's; 2000.
[4] Najafi G, Ghobadian B, Tavakoli T, Yusaf T. Potential of bioethanol production from agricultural wastes in Iran. Renewable and Sustainable Energy Reviews 2009;13(6–7):1418–27.
[5] Bartlett AA. An analysis of U.S. and world oil production patterns using Hubbert-style curves. Mathematical Geology 1999.
[6] Anonymous BP. Amoco statistical review of world energy (1968–2000). London: BP Amoco; 2000.
[7] Anonymous. British Petroleum statistical review of world energy; 2013. Available from: 〈www.bp.com/statisticalreview〉.
[8] Safieddin Ardebili M, Ghobadian, Najafi G, Chegeni A. Biodiesel production potential from edible oil seeds in Iran. Renewable and Sustainable Energy Reviews 2011;15:3041–4.
[9] Mohammadnejad M, Ghazvini M, Mahlia TMI, Andriyana A. A review on energy scenario and sustainable energy in Iran. Renewable and Sustainable Energy Reviews 2011;15:4652–8.
[10] Barat Ghobadian. Liquid biofuels potential and outlook in Iran. Renewable and Sustainable Energy Reviews 2012;16:4379–84.
[11] International Energy Agency (IEA); 2010.
[12] World Energy Outlook (WEO). Alternative policy scenario. International Energy Agency (IEA).
[13] Ghorashi AH, Rahimi A. Renewable and non-renewable energy status in Iran: art of know-how and technology-gaps. Renewable and Sustainable Energy Reviews 2011;15(1):729–36.
[14] Fadai D, Esfandabadi ZS, Abbasi A. Analyzing the causes of non-development of renewable energy-related industries in Iran. Renewable and Sustainable Energy Reviews 2011;15(6):2690–5.
[15] Birur DK, Hertel TW, Tyner WE. The biofuels boom: implications for world food markets. In: Food economy conference; 2007.
[16] Hosseini Seyed Ehsan, Wahid Mazlan Abdul. Feasibility study of biogas production and utilization as a source of renewable energy in Malaysia. Renewable and Sustainable Energy Reviews 2013;19:454–62.
[17] Tabatabaei M, Tohidfar M, Jouzani GS, Safarnejad M, Pazouki M. Biodiesel production from genetically engineered microalgae: future of bioenergy in Iran. Renewable and Sustainable Energy Reviews 2011;15(4):1918–27.
[18] Bagheri Moghaddam N, Mousavi SM, Nasiri M, Moallemi EA, Yousefdehi H. Wind energy status of Iran: evaluating Iran's technological capability in manufacturing wind turbines. Renewable and Sustainable Energy Reviews 15 (8), 2011, 4200–4211.
[19] Parker L, Blodgett J. Greenhouse gas emission: conflicting situations, conflicting perspectives, congressional research service, library of congress 2005.
[20] Anonymous U.S. Energy Information Administration. International Energy Statistics. 〈http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8〉.
[21] Kim S, Dale B. Global potential bioethanol production from wasted crops and crop residues. Biomass Bioenergy 2004;26(4):361–75.
[22] Anonymous. Agricultural Ministry of Iran. In: Statistical book of 2008, vol. 1, part 1. Available at: 〈http://maj.ir/portal/Home/Default.aspx?CategoryID=20ad5e49-c727-4bc9-9254-de648a5f4d52〉.
[23] Seyed Ehsan Hosseini, Mazlan Abdul Wahid. Biogas utilization: experimental investigation on biogas flameless combustion in lab-scale furnace. http://dx.doi.org/10.1016/j.enconman.2013.06.026.
[24] Jain S, Sharma MP. Power generation from MSW of Haridwar city: a feasibility study. Renewable and Sustainable Energy Reviews 2011;15 (1):69–90.
[25] Ashori A, Nourbakhsh A. Characteristics of wood–fiber plastic composites made of recycled materials. Waste Management 2009;29(4):1291–5.
[26] Kathirvale S, Muhd Yunus MY, Sopian K, Samsuddin AH. Energy potential from municipal solid waste in Malaysia. Renewable Energy 2004;29(4):559–67.
[27] Anon. Renewable energy organization of Iran. Biomass projects, Available from: 〈http://suna.ir/ationoffice-zisttoodehoffice-zteproject-fa.html〉.
[28] Hydrocarbon balance 2008. Tehran: Iran Institute for International Energy Studies (IIES); 2010.
[29] Taleghani G, Shabani Kia A. Technical–economical analysis of the Saveh biogas power plant. Renewable energy 2005;30(3):441–6.
[30] Balat M. Use of biomass sources for energy in Turkey and a view to biomass potential. Biomass Bioenergy 2005;29(1):32–41.
[31] Schnepf R. European Union biofuels policy and agriculture: an overview. Congressional Research Service, Library of Congress, Order Code RS22404; 2006.
[32] Biofuels COM. Progress report: report on the progress made in the use of biofuels and other renewable fuels in the member states of the European Union. COM(2006) 845 final. Communication from the Commission to the Council and the European Parliament, Brussels; 2007.

[33] Carriquiry MA. A comparative analysis of the development of the United States and European Union Biodiesel Industries. Briefing Paper; 2007. 07-BP 51.
[34] Balat M, Balat H. Progress in biodiesel processing. Applied Energy 2010;87:1815–35.
[35] Matsumoto N, Sano D, Elder M. Biofuel initiatives in Japan: strategies, policies, and future potential. Applied Energy 2009;86:S69–76.
[36] Zhang C, Xie G, Li S, Ge L, He T. The productive potentials of sweet sorghum ethanol in China. Applied Energy 2010;87:2360–8.
[37] Prabhakar SVRK, Elder M. Biofuels and resource use efficiency in developing Asia: back to basics. Applied Energy 2009;86:S30–6.
[38] Hosseini Seyed Ehsan, Wahid Mazlan Abdul. Necessity of biodiesel utilization as a source of renewable energy in Malaysia. Renewable and Sustainable Energy Reviews 2012;16:5732–40.
[39] Qiu H, Huang J, Yang J, Rozelle S, Zhang Y, Zhang Y, et al. Bioethanol development in China and the potential impacts on its agricultural economy. Applied Energy 2010;87:76–83.
[40] Leduc S, Natarajan K, Dotzauer E, McCallum I, Obersteiner M. Optimizing biodiesel production in India. Applied Energy 2009;86:S125–31.
[41] Suntana AS, Vogt KA, Turnblom EC, Upadhye R. Bio-methanol potential in Indonesia: forest biomass as a source of bio-energy that reduces carbon emissions. Applied Energy 2009;86:S215–21.
[42] Phalan B. The social and environmental impacts of biofuels in Asia: an overview. Applied Energy 2009;86:S21–9.
[43] Kiani Deh Kiani M, Ghobadian B, Tavakoli T, Nikbakht AM, Najafi G. Application of artificial neural networks for the prediction of performance and exhaust emissions in SI engine using ethanol–gasoline blends. Energy 2010;35:65–9.
[44] Najafi G, Yusaf TF, Ghobadian B, Najmeddin VR, Yousif BF. Performance and exhaust emission of a SI engine fuelled with potato waste ethanol and its blends with gasoline. International Energy Journal 2009;10:215–26.
[45] Rahimi H, Ghobadian B, Yusaf T, Najafi G, Khatamifar M. Diesterol: an environment-friendly IC engine fuel. Renewable Energy 2009;34:335–42.
[46] Ghobadian B, Rahimi H, Nikbakht AM, Najafi G, Yusaf TF. Diesel engine performance and exhaust emission analysis using waste cooking biodiesel fuel with an artificial neural network. Renewable Energy 2009;34:976–82.
[47] Gunasekaran P, Raj KC. Ethanol fermentation technology—Zymomonas mobilis. Madurai, India: Department of Microbial Technology, School of Biological Sciences, Madurai Kamaraj University; 2000.
[48] Anonymous. Food and Agricultural Organization (FAO). FAOSTAT. Available at: 〈http://apps.-fao.org/S〉.
[49] Najafi G, Ghobadian B, Yusaf TF. Algae as a sustainable energy source for biofuel production in Iran: a case study. Renewable and Sustainable Energy Reviews 2011;15(8):3870–6.
[50] Anonymous. Agricultural ministry of Iran, the agro-ecological zones, crop production statistics. Available at: 〈http://www.maj.ir/English/Main/Default.AspS〉.
[51] Ghobadian B, Khatamifar M, Rahimi H. Design, fabrication and evaluation of a patent biodiesel processor. In: The international congress on biodiesel: the science and the technology, Vienna, Austria; 2007.
[52] Almassi M, Bakhoda H, Minaee S. Studying suitability of using vegetable oil as alternative fuel. Written for presentation at the 2006 CIGR Section VI international symposium on future of food engineering Warsaw, Poland.
[53] Ameri M, Ghobadian B, Baratian I. Technical comparison of a CHP using various blends of gasohol in an IC engine. Journal of Renewable Energy 2008;33(2008):1469–74.
[54] Ghobadian B, Rahimi H. Biofuels—past, present and future perspectives. In: The fourth international Iran and Russia conference, Shahrekord, Iran, September 8–10, 2004.
[55] Bakhoda H, Almassi M, Mashhadi Meighani H, Nasirian N. A comparison of Camelina Sativa and rapeseed methyl ester as alternative fuels (Biodiesel). Abstracts of the third CIGR-food and agricultural products: processing and innovations, Naples, Italy; 2007.
[56] Ghobadian B. Iran′s policy on renewable energy development. A two days conference on Iran energy forum, upstream and downstream, London, England; 2002.
[57] Ghobadian B, Najafi G, Rahimi H. Future of renewable energies in Iran. In: The sixth Iran national energy congress, Tehran, Iran; 2007.
[58] Ghobadian B, Tavakoli Hashjin T, Rahimi H. Production of bioethanol and sunflower methyl ester and investigation of fuel blend properties. Journal of Agricultural Science and Technology 2008;10:225–32.
[59] Ghobadian B, Najafi G, Rahimi H, Khatamifar M. Comprehensive evaluation of engine performance with diesel and biodiesel. Fuel blends. In: The third international bioenergy conference and exhibition, Finland; September 3–6, 2007.
[60] Najafi G, Ghobadian B, Yusaf TF, Rahimi H. Combustion analysis of a CI engine performance using waste cooking biodiesel fuel with an artificial neural network aid. American Journal of Applied Sciences 2007;4(10):756–64.
[61] Zenouzi A, Ghobadian B. Design and fabrication of a multifunction biodiesel processor. In: International congress on biodiesel, The Science and Technologies, Vienna, Austria; 5–7 November 2007.
[62] Ghobadian B, Rahimi H, Khatamifar M. Experimental evaluation of engine performance using typical diestrol. In: The international congress on biodiesel: the science and the technology, Vienna, Austria; 2007.
[63] Ghobadian B, Ameri M, Baratian I. Economic investigation of ICC HP using gasohol—a case study for Iran. The third international bioenergy conference and exhibition, Finland; September 3–6, 2007.
[64] Yusaf T, Najafi G, Ghobadian B, Najafi B, Pirouzpanah V. Experimental investigation of performance and emission parameters of small diesel engine using CNG and biodiesel. In: Thirteenth small engine technology conference (SETC), Toki Messe, Niigata Convention Center, Niigata, Japan; October 30–November 1, 2007.
[65] Ghobadian B, Khatamifar M, Rahimi H. Biodiesel fuel production using transesterification of waste vegetable oils. In: The fourth international conference on internal combustion engines, Tehran, Iran; November 16–18, 2005.
[66] Ghobadian B, Khatamifar M. Biodiesel fuel production using transesterification of waste vegetable oils. The Journal of Engine Research 2006 (Number 8–9, 2nd/3rd year, Winter/Spring).
[67] Ghobadian B, Rahimi H, Khatamifar M. Evaluation of engine performance using net diesel fuel and biofuel blends. In: The first combustion conference of Iran (CCI1), Tarbiat Modares University, Tehran, Iran; February 15–16, 2006.
[68] Bartle A. Hydropower potential and development activities. Energy Policy 2002;30(14):1231–9.
[69] US Energy Administration Information. Available from: 〈www.eia.gov〉.
[70] Energy balance. Tehran: Iran Ministry of Power; 2010.
[71] World wind energy report 2009. Germany: World Wind Energy Association (WWEA); 2009.
[72] Islam MR, Saidur R, Rahim NA. Assessment of wind energy potentiality at Kudat and Labuan, Malaysia using Weibull distribution function. Energy 2011;36(2):985–92.
[73] Losique J. Wind and water power program, USA; 2010.
[74] Saidur R, Rahim NA, Islam MR, Solangi KH. Environmental impact of wind energy. Renewable and Sustainable Energy Reviews 15(5):2423–30.
[75] Smith J, Thresher R, Zavadil, R, DeMeo E, Piwko R, Ernst B, Ackermann T. A mighty wind. Power and Energy Magazine 7 (2), 2009, 41–51.
[76] World Wind Energy Association (WWEA). World wind energy report 2012. Bonn: World Wind Energy Association; 2012.
[77] Najafi G, Ghobadian B. LLK1694-wind energy resources and development in Iran. Renewable and Sustainable Energy Reviews 2011;15(6):2719–28.
[78] Moslem Mousavi S, Bagheri Ghanbarabadi M, Bagheri Moghadam N. The competitiveness of wind power compared to existing methods of electricity generation in Iran. Energy Policy 2012;42(2012):651–6.
[79] Fadai D. The feasibility of manufacturing wind turbines in Iran. Renewable and Sustainable Energy Reviews 11(3):536–42.
[80] Global Wind Energy Council (GWEC). Global wind energy outlook. Amsterdam: Greenpeace International; 2010.
[81] Hydrocarbon country′s balance sheet in 1387. Tehran: Energy Management Group, Institute for International Energy Studies; 2009.
[82] Iran Energy of Ministry. Energy balance sheet in 1391, Tehran. Tavanir Expert Holding Company; 2011.
[83] Alamdari P, Nematollahi O, Mirhosseini M. Assessment of wind energy in Iran: a review. Renewable and Sustainable Energy Reviews 2011;16(2012):836–60.
[84] Mirhosseini M, Sharifi F, Sedaghat, Assessing the wind energy potential locations in province of Semnan in Iran. Renewable and Sustainable Energy Reviews 15(1):449–59.
[85] Keyhani A, Ghasemi-Varnamkhasti M, Khanali M, Abbaszadeh R. An assessment of wind energy potential as a power generation source in the capital of Iran, Tehran. Energy 35(1):188–201.
[86] Mostafaeipour A. Feasibility study of harnessing wind energy for turbine installation in province of Yazd in Iran. Renewable and Sustainable Energy Reviews 14(1):93–111.
[87] Saeidi D, Mirhosseini M, Sedaghat A, Mostafaeipour A. Feasibility study of wind energy potential in two provinces of Iran: North and South Khorasan. Renewable and Sustainable Energy Reviews 2011;15:3558–69.
[88] Mostafaeipour A, Sedaghat A, Dehghan-Niri AA, Kalantar V. Wind energy feasibility study for city of Shahrbabak in Iran. Renewable and Sustainable Energy Reviews 2011;15(6):2545–56.
[89] Mostafaeipour A. Feasibility study of offshore wind turbine installation in Iran compared with the world. Renewable and Sustainable Energy Reviews 1722–1743;14(7).
[90] Solangi KH, Islam MR, Saidur R, Rahim NA, Fayaz H. A review on global solar energy policy. Renewable and Sustainable Energy Reviews 2011;*15*(4):2149–63.
[91] Jacobson MZ. Review of solutions to global warming, air pollution, and energy security. Energy & Environmental Science 2009;2(2):148–73.
[92] Saidur R, Masjuki H, Hasanuzzaman M, Mahlia T, Tan C, Ooi J, Yoon P. Performance investigation of a solar powered thermoelectric refrigerator. International Journal of Mechanical and Materials Engineering 2008;3(1):7–16.
[93] Islam MR, Saidur R, Rahim NA, Solangi KH. Usage of solar energy and its status in Malaysia. Engineering e-Transaction 2010;5(1):6–10 (ISSN 1823-6379).
[94] Mekhilef S, Saidur R, Safari A. A review on solar energy use in industries. Renewable and Sustainable Energy Reviews 2011;15(4):1777–90.
[95] Saidur R, Masjuki HH, Hasanuzzaman M. Performance of an improved solar car ventilator. International Journal of Mechanical and Materials Engineering 2009;4(1):24–34.

[96] Mirzahosseini Alireza Hajiseyed, Taheri Taraneh. Environmental, technical and financial feasibility study of solar power plants by RETScreen, according to the targeting of energy subsidies in Iran. Renewable and Sustainable Energy Reviews 2012;16:2806–11.
[97] Renewable Energy Sources. Islamic Republic of Iran. Iranian Atomic Energy Agency (IAEA); 2010.
[98] Renewable Energy in Iran. Energy Statistical Review of Iran; 2002. p. 223–39.
[99] Abedi Afshin. Utilization of solar air collectors for heating of Isfahan buildings in IRAN. Energy Procedia 2012;14:1509–14.
[100] Dehghan AA. Status and potentials of renewable energies in Yazd Province-Iran. Renewable and Sustainable Energy Reviews 2011;15:1491–6.
[101] Asnaghi A, Ladjevardi SM. Solar chimney power plant performance in Iran. Renewable and Sustainable Energy Reviews 2012;16:3383–90.
[102] Roozbeh Sangi. Performance evaluation of solar chimney power plants in Iran. Renewable and Sustainable Energy Reviews 2012;16:704–10.
[103] Besarati SM, Padilla RV, Goswami DY, Stefanakos E. The potential of harnessing solar radiation in Iran: generating solar maps and viability study of PV power plants. Renewable Energy 2013;53:193–9.
[104] Ruiz BJ, Rodríguez-Padilla V, Martínez JH. Renewable energy sources in the Mexican electricity sector. Renewable Energy 2008;33(6):1346–53.
[105] Agnolucci P. Renewable electricity policies in The Netherlands. Renewable Energy 2007;32(5):868–83.
[106] Markvart T. Solar electricity. New York: John Wiley; 2002.
[107] Iran Renewable Energy Organization (SUNA) 〈http://www.suna.ir〉.
[108] Kazemi Karegar H, Zahedi A, Ohis V, Taleghani G, Khalaji M. Wind and solar energy developments in Iran. In: The Australasian universities power engineering conference (AUPEC), 〈http://itee.uq.edu.au/~aupec/aupec02/home.pdf〉.
[109] Becker M, Meinecke W, Geyer M, Trieb F, Blanco M, Ro-mero M, Femere A. Solar thermal power plants.The future for renewable energy, prospects and directions. London, UK: Eurec Agency, James & James Science Publishers Ltd; 115–137.
[110] Ghobadian B, Najafi G, Rahimi H, Yusaf TF. Future of renewable energies in Iran. Renewable and Sustainable Energy Reviews 2009;13(3):689–95.
[111] Noorollahi Y, Yousefi H, Itoi R, Ehara S. Geothermal energy resources and development in Iran. Renewable and Sustainable Energy Reviews 2009;13 (5):1127–32.
[112] Martinot E. Renewables 2005 global status report. REN21 Renewable Energy Policy Network/Worldwatch Institute; 2005. p. 14.
[113] Delucchi MA, Jacobson MZ. Providing all global energy with wind, water, and solar power, part II: reliability, system and transmission costs, and policies. Energy Policy 2011;39:1170–90.
[114] Gholamhassan Najafi Barat Ghobadian. Geothermal resources in Iran: the sustainable future. Renewable and Sustainable Energy Reviews 2011;15:3946–51.
[115] Yousefi H, Noorollahi Y, Ehara S, Itoi R, Yousefi A, Fujimitsu Y, et al. Developing the geothermal resources map of Iran. Geothermics 2010;39 (2):140–51.
[116] Porkhial S, Kahrobaeian A. Status of geothermal energy in Iran. In: Ninteenth world energy congress; 2004.